LASER WORDS | MVE | mve˙986 | B | Dispatch: October 6, 2011 | Journal: MVE | CE: Hybrid-CE
Journal Name | Manuscript No. | Author Received: | No of pages: 3 | TS: Suresh

Medical and Veterinary Entomology (2011), doi: 10.1111/j.1365-2915.2011.00986.x

SHORT COMMUNICATION

Evarcha culicivora chooses blood-fed *Anopheles* mosquitoes but other East African jumping spiders do not

R. R. JACKSON[1,2] and X. J. NELSON[1]

[1]Department of Xxx, School of Biological Sciences, University of Canterbury, Christchurch, New Zealand and [2]Department of Xxx, International Centre of Insect Physiology and Ecology, Mbita Point, Kenya

Abstract. Previous research using computer animation and lures made from dead prey has demonstrated that the East African salticid *Evarcha culicivora* Wesolowska & Jackson (Araneae: Salticidae) feeds indirectly on vertebrate blood by actively choosing blood-carrying female mosquitoes as prey, and also that it singles out mosquitoes of the genus *Anopheles* (Diptera: Culicidae) by preference. Here, we demonstrate that *E. culicivora*'s preference is expressed when the species is tested with living prey and that it is unique to *E. culicivora*. As an alternative hypothesis, we considered the possibility that the preference for blood-fed female anopheline mosquitoes might be widespread in East African salticids. When live-prey choice tests were carried out in 19 additional species, there were no instances in which blood-carrying mosquitoes were chosen significantly more often than other prey. Combined with the findings of previous work, these results suggest that it is possible that specialized predators play a role in the biological control of disease vectors.

Key words. *Anopheles gambiae*, *Evarcha culicivora*, foraging, mosquitoes, predation, prey preferences, specialization.

Because they have intricate, vision-guided prey-capture behaviour (Jackson & Pollard, 1996) and the ability to see fine detail (Harland *et al*., 2011), jumping spiders (Salticidae) are especially suitable subjects in experiments on prey-choice behaviour (Nelson & Jackson, 2011). There are numerous examples of salticids expressing distinctive preferences for other spiders or for ants (Jackson & Pollard, 1996). However, it may be that the East African salticid *Evarcha culicivora* Wesolowska & Jackson, the natural prey of which consists mainly of mosquitoes (Wesolowska & Jackson, 2003), illustrates the most unexpected precision in prey-choice behaviour. This is a spider that feeds indirectly on vertebrate blood by actively choosing blood-fed female mosquitoes as prey (Jackson *et al*., 2005), and it also expresses a preference for *Anopheles* (Nelson & Jackson, 2006), the mosquito genus to which all human malaria vectors belong (Clements, 1999).

Experiments based on using motionless lures and/or virtual prey generated by computer animation have demonstrated that *E. culicivora* makes fine discriminations between anopheline and less preferred culicine mosquitoes, even when it is restricted to visual cues alone (Jackson *et al*., 2005; Nelson & Jackson, 2006). Filling an important gap left by earlier work, we confirm that *E. culicivora* makes prey-choice decisions that deliver bloodmeals when living prey are used in experiments. We also consider an alternative to our hypothesis that *E. culicivora*'s specialized preferences are unique or at least exceedingly unusual. The alternative hypothesis is that preference for blood-carrying mosquitoes is widespread in East African salticids. We addressed this hypothesis by undertaking identical experiments using another 19 East African salticid species.

All testing was carried out between 08.00 hours and 19.00 hours (in a laboratory photoperiod of LD 12 : 12 h, with lights on at 07.00 hours) using spiders that had been starved for 7 days prior to testing. All test spiders (always $n > 20$) were adult females that had matured in laboratory culture 2–3 weeks

Correspondence: Ximena J. Nelson, Department of Xxx, School of Biological Sciences, University of Canterbury, Private Bag 4800, Christchurch 8081, New Zealand. Tel.: +64 3 364 2987 (ext. 4050); Fax: +64 3 364 2590; E-mail: ximena.nelson@canterbury.ac.nz

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Table 1. Simultaneous-presentation tests of female salticids (Araneae: Salticidae).

Salticid species	Prey 2†	Chose prey 1*, *n*	Chose prey 2†, *n*	χ^2
Evarcha culicivora	*C. claripennis*	20	5	9.000‡
	An. gambiae, M	18	2	12.800§
Asemonea murphyae Wanless	*C. claripennis*	12	15	0.333
	An. gambiae, M	15	15	0.000
Cyrba ocellata (Kroneberg)	*C. claripennis*	14	14	0.000
	An. gambiae, M	13	13	0.000
Goleba puella (Simon)	*C. claripennis*	18	14	0.500
	An. gambiae, M	17	17	0.000
Harmochirus brachiatus (Thorell)	*C. claripennis*	20	14	1.059
	An. gambiae, M	15	16	0.032
Hasarius adansoni (Savigny & Audouin)	*C. claripennis*	16	16	0.000
	An. gambiae, M	15	18	0.273
Holcolaetis vellerea (Simon)	*C. claripennis*	17	18	0.000
	An. gambiae, M	14	16	0.133
Hyllus sp.	*C. claripennis*	12	15	0.333
	An. gambiae, M	18	15	0.273
Meleon solitaria	*C. claripennis*	19	15	0.471
	An. gambiae, M	16	17	0.030
Menemerus bivittatus (Dufour)	*C. claripennis*	14	16	0.133
	An. gambiae, M	17	18	0.029
Menemerus congoensis Lessert	*C. claripennis*	16	16	0.000
	An. gambiae, M	14	15	0.034
Menemerus sp.	*C. claripennis*	19	13	1.125
	An. gambiae, M	16	16	0.000
Myrmarachne melanotarsa Wesolowska & Salm	*C. claripennis*	14	13	0.037
	An. gambiae, M	15	12	0.333
Natta rufopicta (Simon)	*C. claripennis*	16	11	0.926
	An. gambiae, M	15	15	0.000
Pachyballus cordiformis Berland & Millot	*C. claripennis*	13	15	0.143
	An. gambiae, M	13	15	0.143
Parajotus cinereus Wesolowska	*C. claripennis*	18	15	0.273
	An. gambiae, M	19	16	0.257
Plexippus sp.	*C. claripennis*	19	15	0.471
	An. gambiae, M	19	15	0.471
Portia africana	*C. claripennis*	14	16	0.133
	An. gambiae, M	18	14	0.500
Pseudicius sp. (Simon)	*C. claripennis*	15	10	1.000
	An. gambiae, M	15	15	0.000
Thyene sp.	*C. claripennis*	16	16	0.000
	An. gambiae, M	15	20	0.714

*Prey 1: blood-fed *Anopheles gambiae*, female.
†Prey 2: *Clinotanypus claripennis* (male or female) or *Anopheles gambiae*, male (M).
χ^2 tests of goodness of fit: ‡$P < 0.01$; §$P < 0.001$; all other rows $P > 0.05$.

before being used. Spiders were housed individually in spacious cages enriched with a meshwork of twigs. Spiders were reared on a mixed diet of non-biting midges collected locally, as well as on male and female mosquitoes (spiders were given unlimited access to all prey types three times per week). Mosquitoes used for rearing were *Anopheles gambiae* s.s. Giles from laboratory culture (Jackson *et al*., 2005). In culture, all mosquitoes had continuous access to glucose (6% solution) and only sugar-fed mosquitoes were used as maintenance prey for the spider cultures. The expression 'blood-fed' refers to female mosquitoes that had received a bloodmeal (from a human host) 4 h before being used in a prey-choice test.

During prey-choice testing, one prey was always a blood-fed *An. gambiae* female. The other prey was either a male or a male or female midge [*Clinotanypus claripennis* Kieffer (Diptera: Chironomidae)]. All prey were 5.0 mm in body length (accurate to the nearest 0.5 mm). Tests were carried out in a glass arena (100 × 100 × 35 mm), with a removable glass lid (100 × 100 mm). A hole (diameter 16 mm) in the centre of the floor, situated 10 mm from one end of the box and plugged with a removable rubber bung, was used to introduce prey and the test spider into the arena. To begin testing, a test spider was allowed to enter through the hole once two live prey were in the arena. Trials ended when the salticid captured and began feeding on one of the two prey items.

When *E. culicivora* was used in the prey-choice tests, significantly more test spiders chose blood-fed mosquitoes than the alternative prey (Table 1). However, when the other

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19 salticid species were tested, the number of test spiders that chose blood-fed mosquitoes did not differ significantly from the number that chose the alternative prey, although all methods were identical to those used with *E. culicivora* and the sample size was always equal to or larger than that used when testing *E. culicivora*. These findings confirm that *E. culicivora* expresses prey-choice behaviour with living prey comparable with that shown earlier with lures and virtual prey, and provide no support for the hypothesis that choosing among blood-fed mosquitoes is widespread in East African salticids. Combined with the findings of previous work (Wesolowska & Jackson, 2003; Jackson *et al*., 2005; Nelson & Jackson, 2006), these results suggest that the notion that specialized predators have a role in the biological control of disease vectors may be a realistic possibility.

Acknowledgements

We thank Godfrey Otieno Sune, Stephen Abok Aluoch, Silas Ouko Orima and Jane Atieno Obanyo for technical assistance at the International Centre of Insect Physiology and Ecology. This research was supported by the Royal Society of New Zealand, the National Geographic Society and the National Institutes of Health.

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Accepted dd Month 2011

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